DEA for Establishing Performance Evaluation Models: a Case Study of a Ford Car Dealer in Taiwan

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Abstract:

Effective resource allocation brings better enterprise competitiveness. This study, taking Ford-Right, a Ford Car dealer in Taiwan, as an example, integrates data from enterprise system (ES) and Dealer Management System (DMS) to establish performance evaluation models in sales sites. Performance evaluation model was combined with Data Envelopment Analysis (DEA) so as to analyze relative efficiency of different service centers. This study included eleven service centers of Ford-Right and originally incorporated two inputs and three outputs, one of which was removed because of negative correlation with other variables. Empirical results identified five relatively efficient service centers. In addition, through slack variable analysis, DEA helped to find critical variable for improvement and served as references to reach target performance of respective service center.

Key words: Data Envelopment Analysis (DEA), slack variable analysis, Key Performance Indicator (KPI), performance evaluation

1 Introduction

In Taiwan, automobile sales shrank from 514,627 in 2005 to 378,228 in 2011, causing keen competition in the market. With an attempt to improve operating efficiency and to lower down operating cost as for more rapid time to market and real-time function, car selling companies introduce diversifying information systems such as Enterprise Resource Planning (ERP), Dealer Management System (DMS) and Customer Relationship Management (CRM), making rapid information transfer among department, systems and business units. Beneficial tools for competitive advantage include electronic operating procedure and data integration in every information system, providing better suggestions for decision making and better competitiveness.

The core of the application of information systems is ERP. All information systems in one specific enterprise are integrated and combined in package software which is used for improving productivity, for reducing costs and for improving customer service (Ifinedo, 2007). ERP integrates internal information and provides real-time information for users, especially for executives. For business executives, being able to control all information relating to decision making at any time is critical for better decision making quality and for reducing decision making risks. Relevant studies have proven that successful ERP leads better competitive advantages (Wang et al., 2007).

However, with information technology advancement, all systems are linked complexly, causing vague boundaries of systems. We have difficulties to certainly determine which function is reserved for the use of specific system. Therefore, all systems in the enterprise are generally called Enterprise Systems (ES). Unfortunately, for most of the management information systems, it is inclined to focus on records of business transactions and business operations but improve decision support capability (Holsapple & Senab, 2005).

To this end , what ES provides is data. These data need time or manpower to be searched, arranged and analyzed to provide suggestions and reference for decision making. Such procedure is time consuming and manpower consuming which will weaken business competitiveness. This study is aimed to develop a performance evaluation model which integrates data and information, expecting to assist business managers

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for more efficient and correct decision and to lower decision risks.

Therefore, the present study applied Data Envelopment Analysis (DEA), a common and reliable method, to evaluate performance of automobile service centers. DEA takes into account multiple inputs and outputs and is suitable for analyze relative efficiency of multiple departments. Moreover, information system data can be updated promptly and continuously for designing performance evaluation model, providing novel and rapid suggestions for business managers in order to meet rapidly changing market.

2 Literature Review

2.1 Taiwan's Automobile Selling Industry

The automobile industry in Taiwan is categorized into two markets, namely market of domestic brands and market of foreign brands. However, for both markets either of domestic brands or foreign brands, they all step forward for the same direction which is to increase market share, to increase sales, etc. Thus, manufacturers of domestic brands and agents of foreign brands usually set sales targets to dealers in order to increase the market share. In addition, distribution system of all brands is very similar. The automobile market in Taiwan includes four sections – north, central, south and east sections. Car manufacturers seek capable dealers in each section or establish sub-branch companies to sell their cars and to provide maintenance and repair services.

In recent years, Sales of domestic brands has shrunk by 36.73% from 444,470 in 2005 to 281,198. The decline is much larger than the decline in the whole market. Consequently, there is dramatic competition among dealers of diversifying brands. Efficient operation and management is required to triumph in the competition. All managers aim to stride forward for electronilization and introduction of enterprise system in the recent decade. Manufactureres or general agents of each brand all provide with dealers with guidance and assistance to introduce dealership management system (DMS). However, the system is designed according to the mfanucturers' management needs. Operating management needs from dealers are not considered completely. Therefore, most of the dealers develop enterprise systemsor enterprise resource planning system of their own.

2.2 From Enterprise Resource Planning (ERP) to Enterprise System (ES)

Recent business operators rely more on management information systems to gather business information for making critical decisions (Bendoly et al., 2008). In Taiwan, most enterprises of certain scale not only in manufacturing industry or service industry have introduced management information system or enterprise resource planning system to improve operating efficiency.

ERP is aimed to improve the efficiency of daily affairs through standardized procedure and data (Cebeci, 2009). ERP is capable of providing total and real-time operating information of companies. It is a challenging task to develop and introduce ERP in an organization. Possible scopes include the selection and allocation of ERP software and modification of business procedure for smooth ERP development and familiarity of operators (Malhotraa & Temponib, 2010). Technology, manpower, organization, economy are all involved in ERP. Especially for car dealership and maintenance, every single car undergoes the entire process from inventory to sales, maintenance and repairs. Hence, more and more companies have introduced ERP systems or enterprise systems of their own. Enterprise systems are an integrated planning and resource management system, coordinating functional operations in departments. Sometimes, enterprise systems are better than ERP. Enterprise systems are capable of integrating supply chain management (SCM), customer relationship management (CRM), supplier relationship management (SRM), and product lifecycle management (PLM) (Bendoly & Jacobs, 2005).

In recent years, ERP systems in automobile selling industry are transformed as enterprise systems because car dealers need SRM systems to integrate and manage agents and raw material suppliers. Business operations and management is assisted by ERP systems. Customer service capabilities are strengthen with CRM systems. As a result, more and more car dealers have been endeavouring their efforts to develop enterprise systems of their own, integrating information in all systems for effective application.

Nevertheless, most of the systems are connected vertically or horizontally or databases are integrated to improve operating efficiency when enterprises develop enterprise systems.

2.3 Decision Support System (DSS)

Electronilization of middle and small enterprises in Taiwan has been greatly improved and many enterprises have developed enterprise systems of their own. However, most of the systems are functioned with daily management containing real-time transaction data or inventory records, being unable to provide managers with managerial suggestions or decision supports. Same development trend are shown in foreign studies (Holsapple & Senab, 2005). In most of the enterprise systems or management information systems, it is more inclined to record business transactions and operating data but to improve decision support capability. In a research about the link between enterprise resource planning (ERP) systems and internal/external data, new ERP systems shall be capable of generating business intelligence that matters. Many studies have proven that information in ERP systems can provide with better decision support. There are more researches verify that ERP can be functioned to be decision-supported (Li, 1999).

Holsapple & Senab (2005) believe that further comprehension in ERP objectives, decision making advantages and links among them can be of benefit to ERP planners. Therefore, is it expected that efficiency, quality, cost and speed of decision making will be improved because this study takes basis on the databases of ERP or ES as for decision making. As a result, this study is trying to present a performance evaluation model to be assisted in human resource decision support.

2.4 Performance Evaluation

With increasing competition in business environment, business managers make every effort to seek for an effective and fair performance evaluation model, putting daily management into practice and improving competitiveness in return.

Basic concept for management is to acquire the maximum of output or provide with more services with the minimum of input. Performance evaluation is the process of measuring relative outcomes of inputs and outputs. In literature, a number of performance management and evaluation methods are suggested, such as KPI, Balanced scorecard and etc. Unfortunately, few are adopted in business practices, mainly because of complexity of implementation. Manager or practitioners have difficulties in understanding or applying these tools. A commonly-used method for performance evaluation for middle and small enterprises in Taiwan is KPI. However, most enterprises are attempting to find the best and suitable method in measuring department performance. By setting optimum policies and feedback, improvement of performance and better business outcomes is expected.

2.4.1Key Performance Indicator (KPI)

Key Performance Indicator (KPI) is an objective measurement method with settlement, selection, calculation and analysis to evaluation process performance. Business objectives are decomposed with operational objectives, which is the basis for performance evaluation in enterprises. KEP helps to precisely identify major tasks of department managers. Performance evaluation index is determined accordingly. Establishing clear and feasible KPI is the key to successful performance evaluation.

KPI is applied for performance evaluation. Though it is commonly practiced and is easy to be understood by managers, there are still some problems to be solved in real practices. For example, as it is highly correlated with employees' benefits, the focus shall be on fairness and justice. Sometimes, same measurement is adopted to evaluate units with different characteristics. Therefore, there is doubt about whether the standard is objective and correct. This is highly related to the ability of KPI designers if they can effectively control right KPI or not. In business practice, KPI designers usually duplicate or include highly-related indicators, bringing ineffective results.

2.4.2 Data Envelopment Analysis (DEA)

DEA applies the concept of Production Possibility Curve (PPC) in Economics to evaluate productive efficiency of decision making units (DMUs). By selecting multiple inputs and outputs, linear programming is utilized to find the efficiency frontier. Any DMU on the frontier is considered relatively efficient while any one not on the frontier is considered inefficient.

The major advantage that DEA has is its ability to incorporate multi-inputs and multi-outputs to compare relative efficiency of DMUs without assuming production function in advance. Weights of inputs and outputs in DEA are obtained through linear programming, which is more objective. As efficiency frontier is connected with the points with the best conditions of DMUs, it functions as to compare efficiency of different DMUs. Analysis results are more likely to be accepted by all DMUs. Therefore, this study applies DEA as performance evaluation model. For example, Lee & Saen (2012) empirically employed DEA to measure corporate sustainability management in the electronic industry in Korea. Yand & Liu (2012) also introduced DEA for evaluating managerial efficiency of bank branches in Taiwan, helping bank management to reach directions for improvement.

3 Methodology

Building on the ideas of Farrell (1957), Charnes et al. (1978) applied linear programming to estimate an empirical production technology frontier for the first time in their use of multiple inputs to produce multiple outputs. Since then, there have been a large number of books and journal articles written on DEA or applying DEA on various sets of problems.

3.1 CCR model

Building on Farrell's ideas, Charnes et al. (1978) expanded Farrell's efficiency measurement concept of multiple inputs and single output to the concept of multiple inputs and multiple outputs. They utilized linear combination to convert it to single virtual input and output, estimated efficiency frontier from the ratio of two linear combinations, and measured the relative efficiency of each DMU in CRS, which is between 0 and 1 and can determine whether a DMU is in constant, increasing or decreasing returns to scale.

3.2 BCC model

Banker et al. (1984) widened the CCR model ratio concept and application scope in both Farrell and CCR models; efficiency was supposed to measure in CRS, but inefficiency might not have allocative efficiency, proper scale, and technical efficiency. Therefore, BCC changed CCR to variable returns to scale (VRS) hypothesis, broke down technical efficiency into pure technical efficiency and scale efficiency, and measured its efficiency and returns to scale.

4 Case study

4.1 Selection of Research Subjects and Data Source

Ford-Right Co., Ltd., the biggest Ford Car dealer in Taiwan, was established on April 29 for the integration purpose of four dealers in Tainan. It serves as the exclusive distributor of FORD Lio Ho Motor Company Ltd. in Yulin, Ciayi and Tainan. Business items include automobile trading, repair and maintenance service, parts and accessories trading, examination service, automobile loan, automobile insurance and second-hand trading. Currently, Ford-Right has 11 service centers which have been selected as DMUs for performance assessment. They are coded as DMU1 to DMU11.

4.2 Inputs and Outputs

In selecting the inputs and outputs for evaluating the operating efficiency of DMUs, we have done a series of thorough interviews with respective responsible directors and the CEO of Ford-Right. Current key performance indicators are referred as well. DEA model is adopted as performance evaluation model in Ford-Right and five variables are incorporated in this study to evaluate efficiency of service centers. Two inputs are selected such as the number of technicians and the number of repair orders. Repair sales of other brands, and the average expenditure, and customer value performance are three output variables. The isotonicity assumption suggested by Bowlin (1987) among inputs and outputs should be validated by conducting correlation analysis. As revealed in Table 4.1, negative correlations between customers' value performance and the number of technicians and between customer value performance and repair sales of other brands. The isotonicity assumption was against; therefore, customer value performance was removed from the output variable list. Finally, the number of variables used for this study thereafter adheres to the DEA convention suggested by Bowlin (1987) to be small or equal to one-third of the number of DMUs. Table 4.2 shows the original input and output data of DMUs.

Correlation	Number of Technicians	Number of Repair Orders	Repair Sales of Other Brands	Average Expenditure	CVP
Number of Technicians	1.0000	0.7562	0.6425	0.7881	-0.1979
Number of Repair Orders	-	1.0000	0.5100	0.7963	0.0741

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Repair Sales of Other Brands	-	-	1.0000	0.4935	-0.0803
Average Expenditure	-	-	-	1.0000	0.2724
CVP	-	-	-	-	1.0000

Source: Ford-Right Co., Ltd.

Table 4.1 Correlation matrix between inputs and outputs

DMU	**Inputs**		**Outputs**	
	Number of Technicians	**Number of Repair Orders**	**Repair Sales of Other Brands**	**Average Expenditure**
DMU1	22	1,035	160,969	111,363.5
DMU2	9	914	41,142	88,639.5
DMU3	10	934	230,081	30,092.0
DMU4	24	1,257	357,993	227,339.5
DMU5	21	1,244	259,627	134,187.5
DMU6	4	891	124,953	26,192.0
DMU7	11	1,209	88,937	124,604.5
DMU8	17	1,067	452,004	146,299.5
DMU9	8	912	49,506	66,217.5
DMU10	10	944	40,110	117,344.0
DMU11	12	1,029	67,166	116,165.5

Source: Ford-Right Co., Ltd.

Table 4.2 Original input and output data of DMUs

5 Empirical Results

According to the study objective, data envelopment analysis of inputs and outputs has been carried out using CCR assumptions. DEA-Solver Software is utilized and all results are shown accordingly. Table 5.1 shows the summary statistics for the inputs and outputs incorporated in the study.

Correlation	**Number of Technicians**	**Number of Repair Orders**	**Repair Sales of Other Brands**	**Average Expenditure**
Mean	13.455	1,039.636	170226.182	108,040.455
S.D.	6.214	132.477	132720.218	53,698.108
Max.	24.000	1,257.000	452,004.000	227,339.500
Min.	4.000	891.000	40,110.000	26,192.000

Table 5.1 Summary statistics for the inputs and outputs

5.1 Efficiency Analysis

CCR efficiency, reference groups, rank and reference frequency are shown in Table 5.2. The results showed that there were five efficient service centers with efficiency score equal to 1, namely DMU4, 6, 7, 8 and 10. The remaining six service centers were considered as relatively inefficient DMUs as they have CCR efficiency values lower than 1. In addition, among these six efficient service centers, DMU8 was identified as the most valuable benchmark as it was referred four times by other DMUs.

DMU	Inputs		Outputs	
	CCR Efficiency	Reference groups	Rank	Frequency
DMU1	0.5949	4	11	0
DMU2	0.8492	7, 10	7	0
DMU3	0.8373	6, 8	8	0
DMU4	1.0000		1	3
DMU5	0.6834	4, 8, 10	10	0
DMU6	1.0000		1	1
DMU7	1.0000		1	2
DMU8	1.0000		1	4
DMU9	0.7340	7, 8	9	0
DMU10	1.0000		1	3
DMU11	0.8609	4, 8, 10	6	0

Table 5.2 Efficiency analysis for service centers of Ford-Right

5.2 Slack variable analysis

Slack variable analysis is one of the most valuable analysis methods in DEA, which was used for researchers to find critical variables to be improved. Results of slack variable analysis are shown in Table 5.3. For those efficient DMUs, there is no room for improvement as the slack variables in inputs and outputs are all 0. However, for those inefficient DMUs, their target performance can be reached by reducing inputs and increasing outputs. By combining the slack variables from Table 5.3 and the original data from Table 4.2, target performance and improvement potential for each DMU is shown in Table 5.4.

Taking DMU1 with a CCR efficiency of 59.49% for example, the original data are (22, 1035) for its inputs and (160969, 111,363.5) for its outputs respectively, and slack variables are (1.3318, 0) for its inputs and (14395.8330, 0) for its outputs. That is, to become an efficient DMU, DMU1 has to cut its " number of technicians" by 10 [22*(1-0.5949)+1.3318)≒ 10], to cut its " number of repair orders" by 419 [1035*(1-0.5949)+0)≒ 419], and to increase its " repair sales of other brands" by 14396. This result can provide relevant information for managers to evaluate its performance.

DMU	CCR Efficiency	Inputs		Outputs	
		Number of Technicians	Number of Repair Orders	Repair Sales of Other Brands	Average Expenditure
DMU1	0.5949	1.3318	0	14395.8330	0
DMU2	0.8492	0	14.7739	0	0
DMU3	0.8373	0	0	0	38665.5680
DMU4	1.0000	0	0	0	0
DMU5	0.6834	0	0	0	0
DMU6	1.0000	0	0	0	0
DMU7	1.0000	0	0	0	0
DMU8	1.0000	0	0	0	0
DMU9	0.7340	0	29.1936	0	0
DMU10	1.0000	0	0	0	0
DMU11	0.8609	0	0	0	0

Table 5.3 Slack variable analysis results

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DMU	Item	Inputs		Outputs	
		Number of Technicians	Number of Repair Orders	Repair Sales of Other Brands	Average Expenditure
DMU1	Original	22	1,035	160,969	111,363.5
	Difference	-10	-419	14396	0
	Target	12	616	175365	111,363.5
DMU2	Original	9	614	41,142	88,639.5
	Difference	-1	-153	0	0
	Target	8	761	41,142	88,639.5
DMU3	Original	10	934	230,081	30,092.0
	Difference	-2	-152	0	38,665.6
	Target	8	782	230,081	68757.6
DMU5	Original	21	1,244	259,627	134,187.5
	Difference	-7	-394	0	0
	Target	14	850	259,627	134,187.5
DMU9	Original	8	912	49,506	66,217.5
	Difference	-2	-272	0	0
	Target	6	640	49,506	66,217.5
DMU11	Original	12	1,029	67,166	116,165.5
	Difference	-2	-143	0	0
	Target	10	886	67,166	116,165.5

Table 5.4 Improvement potential

6 Discussions and Conclusions

This study employs the DEA for performance evaluation of 11 service centers of Ford-Right, a Ford car dealer in Taiwan. The application of DEA could improve the shortcomings of single performance measurement with the consideration of influential inputs and outputs during the observation period. Our empirical results indicated 5 efficient service centers. Moreover, DMU8 was identified as the most valuable benchmark as it was referred four times by other DMUs. The application of DEA in establishing performance evaluation models was verified.

Resource can be allocated more effectively according to DEA results. As found from slack variable analysis, DMU1, for example, shall decrease its “number of technicians” by 10, decrease its “number of repair orders” by 419, and increase its “repair sales of other brands” by 14396 in order to become a relatively efficient DMU. The findings are helpful for performance improvement in which they could benchmark practices being adapted by the most efficient service center. For non-adjustable resource, managers can further examine internal causes and find better solution. Manager can adjust the weights of KPI for the next month according to DEA results as well, assisting managerial decision making.

At least five implications for business practices were presented. First, performance evaluation models help to measure operating performance of DMUs and the results were considered as reference for managers to do decision making. Second, the empirical results help to ensure relative efficiency of DMUs. Managers could further capture development status of every DMU and allocate resource accordingly. Third, real-time analysis results could be referred as daily management in order to indirectly improve performance. Fourth, the empirical results could be referred for designing the functions of DMS in the future. Finally, performance evaluation models in this study could be adopted for measuring efficiency of dealership in the automobile selling industry in China.

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